Investigation

CONVERSIONS THAT MAKE CENTS

Background Information

If you are not driving already, you probably will be soon. And in the near future, you may be faced with the task of buying a car. In the business world, people use a system called **cost-benefit analysis** to help them decide whether to make a financial investment, such as purchasing a car, equipment or other goods. Typically, a cost-benefit analysis is used to figure out either how much money will be saved or how much the change will cost.

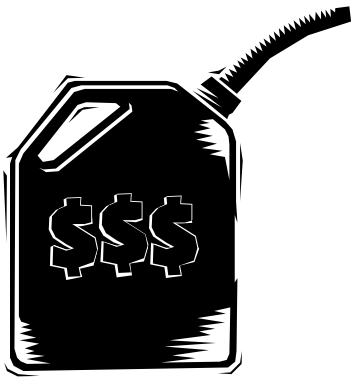


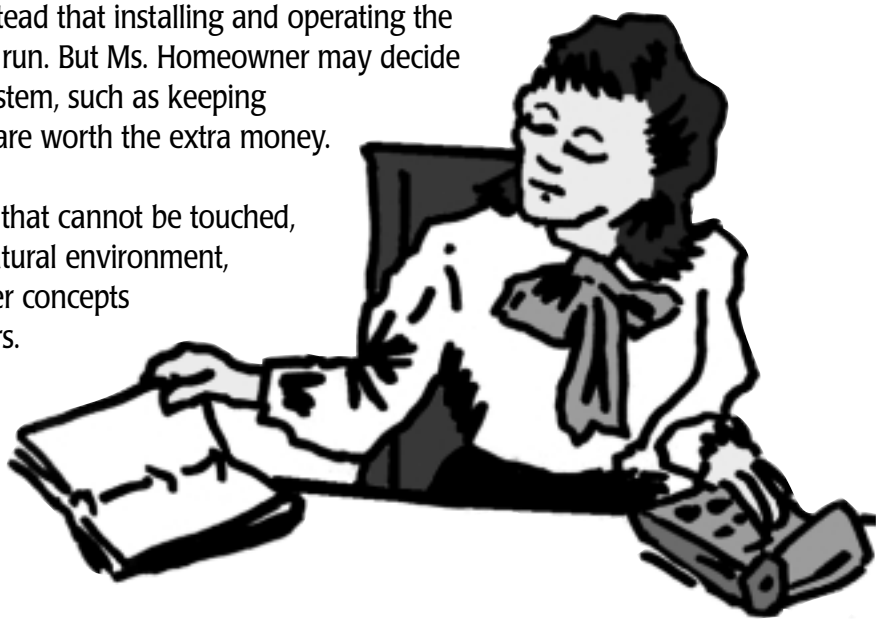
Figure 2-4-4 *One factor to consider when choosing a fuel is operating costs, which include fuel costs.*

For example, in deciding whether to buy an energy-efficient air conditioner a homeowner would consider several factors. One would be the cost to buy and install the new appliance. Another would be how much money would be saved on electricity bills and maintenance (**operating costs**), and how long the appliance would probably last (**useful life**). Mr. and/or Ms. Homeowner would compare these with the equivalent figures for staying with their current air conditioner.

Sometimes the goal of making an investment is to save money in the long run. In the preceding example, Ms. Homeowner may find that she will save enough over the useful life of the air conditioning system to make her money back.

Figure 2-4-5 *Often, a cost-benefit analysis is called a **life-cycle analysis** because the "life" of the equipment is a crucial part of the calculation.*

The cost-benefit calculation may show instead that installing and operating the new equipment will cost more in the long run. But Ms. Homeowner may decide that the **intangible benefits** of the new system, such as keeping herself and her family more comfortable, are worth the extra money.



The word "intangible" refers to something that cannot be touched, such as societal benefits, protecting the natural environment, emotions, comfort, quality of life, and other concepts difficult or impossible to reduce to numbers.

The result of a cost-benefit analysis is a key factor to be considered in decision-making. However, it does not automatically answer the question, "Should I make this investment?"

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CONVERSIONS THAT MAKE CENTS INVESTIGATION CONT.

Going Green

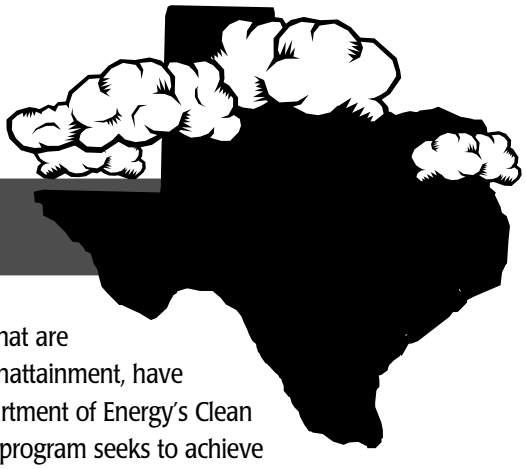
Before replacing a business or personal vehicle to an alternative fuel, the user must consider many factors. People who manage vehicle **fleets** have a particular responsibility to keep costs down.

One critical calculation is fuel cost. The amount of fuel a vehicle currently uses (usually expressed in miles per gallon), how far the vehicle travels each year, and the basic cost of the fuel must be known. For compressed natural gas and propane, costs can be figured in "**miles per gasoline gallon equivalent**" (mpge) so they can be easily compared to liquid fuels that are sold by the gallon. One gasoline gallon equivalent is the amount of an alternative fuel that contains the same amount of energy (in Btu's) as one gallon of gasoline (Appendices pg. 410).

Of course, a big expense when switching to alternative fuels is the purchase price of a new vehicle from an **original equipment manufacturer** (OEM) already equipped to run on an alternative fuel. However, because this is not a cost that you will have to pay every year, you should divide the **price premium** by the number of years the vehicle will be used. This calculation process is called **amortization**.

Another way to take the original vehicle cost into consideration is to figure total operating costs for the lifetime of the vehicle, and add the entire cost to the result.

Cleaning Up Texas' Air



Four Texas metropolitan areas have failed to attain the air-quality standards for ozone set forth in the 1990 amendments to the federal Clean Air Act. Ozone is an irritating gas that is a principal component of smog. Nonattainment cities have submitted plans committing them to cleaning up their air by a certain date.

The Texas ozone nonattainment areas are Houston-Galveston-Brazoria (severe), El Paso (serious), and Beaumont-Port Arthur and Dallas-Fort Worth (moderate). El Paso is also in nonattainment for carbon monoxide.

Concerned citizens and groups in some of these cities, as well as other cities that are close to being in nonattainment, have joined the U.S. Department of Energy's Clean Cities program. The program seeks to achieve cleaner air through awareness of pollution problems and use of alternative fuels. Some Clean Cities offer financial incentives for converting to alternative fuels.

Areas in Texas designated as Clean Cities are Austin, Corpus Christi, Dallas-Fort Worth, Houston-Galveston, San Antonio and Paso del Norte (El Paso).

CONVERSIONS THAT MAKE CENTS
INVESTIGATION CONT.

Procedure

1. Read through the background, paying particular attention to factors involved in a cost-benefit analysis.

2. List five factors used in a cost-benefit analysis of switching to an alternative fuel vehicle.

   _____ _____

   _____ _____

   _____

3. Your teacher will place you in a group and assign you a scenario. The scenarios are fictitious but are based on real situations.

4. Read the scenario with your group and discuss any special needs or limitations identified.

5. Your group will now prepare to calculate the factors of replacing the vehicles in your scenario to compressed natural gas (CNG), propane, ethanol, methanol, biodiesel and flex fuel (using gasoline or another fuel). You will compare these to the costs of gasoline vehicles.

   Using the charts and tables your teacher will provide, and the scenario and background, find the following:

   A. How many vehicles will need to be replaced? Check your scenario and enter that number by the "N" on your worksheet (figure 2-4-12a).
   B. How far will each vehicle travel each year? Check your scenario, calculate the correct number, and enter it by the "M" on your worksheet.
   C. How many miles per gallon equivalent does your vehicle get when running on conventional fuel (gasoline)? Check your scenario and enter the amount by the "G" on your worksheet.
   D. Read the scenario and page 411 in the appendices to identify the vehicle life expectancy. Enter this number by the "L" on your worksheet.

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CONVERSIONS THAT MAKE CENTS INVESTIGATION CONT.

E. Consult the charts provided on page 410 in the appendices with the figures for MPGE decrease factor "D," equipment cost "E," and cost per gallon equivalent "F." Enter the appropriate number for each fuel.

6. You have now completed a comparisons table that identifies several cost factors related to the replacement of a vehicle with an alternative fuel vehicle. How do you think you can use these factors to calculate the costs of switching to an alternative fuel? Discuss this with your group and write a brief answer.

_____

_____

_____

7. As a group, try to write a generic formula for the cost of vehicle replacement using the variables shown on your worksheet. Use the letter symbol of each variable in your formula. Don't worry about getting the correct answer; just try to make an educated guess.

Cost per year = _____

8. Then, compare your formula to the correct formula your teacher will show you. Is the correct formula different from your formula? Why do you think this is so? Enter the correct generic formula at the bottom of worksheet 2-4-12a.

9. For each fuel, plug your variables into the correct formula and calculate (Figure 2-4-12b). *Note that for gasoline and ethanol you only have to calculate the fuel costs because extra equipment costs do not apply.* Round figures up to two places past the decimal. Round the cost per year to the nearest dollar amount.

10. After you have performed the calculations, answer the following questions:

A. What are the least expensive and most expensive options in terms of fuel costs?

_____

B. What are the least expensive and most expensive options in terms of purchase price?

_____

_____

CONVERSIONS THAT MAKE CENTS INVESTIGATION CONT.

C. When you factor in all the costs and savings, what is the least expensive alternative fuel vehicle for your scenario?

_____

D. Calculate and compare the cost of using the least expensive alternative fuel with the cost of continuing to use conventional fuels. Is it more or less expensive? _____

$$\frac{\text{number of vehicles} \times \text{mileage of vehicle per year}}{\text{conventional mpg}} \times \text{price per gallon equivalent} = \text{annual fuel costs}$$

$$\frac{\quad}{\quad} \times \quad \times \quad =$$

E. If it is more expensive, do you think it is affordable to the user in your scenario?

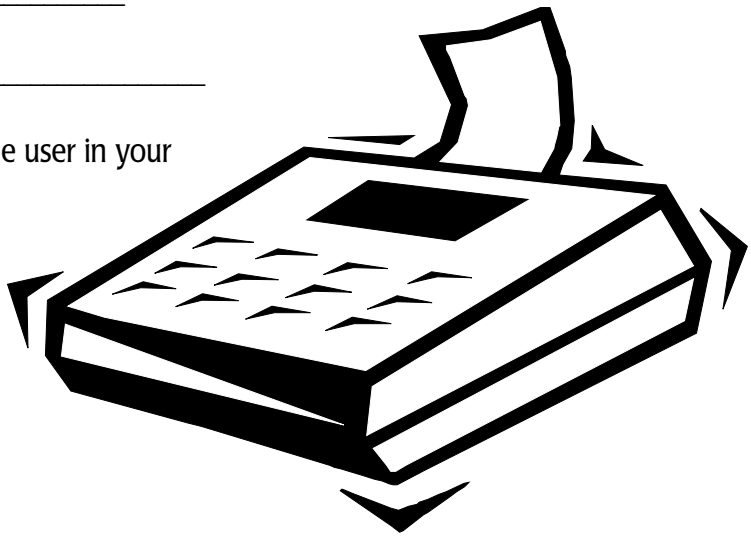
_____

F. Are there any intangible benefits for the user in your scenario?

_____

_____

G. As a group, what is the best recommendation to the user in your scenario?



_____

_____

_____

H. What are some other factors not addressed in this scenario that might affect the cost of benefits? _____

_____

_____

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CONVERSIONS THAT MAKE CENTS INVESTIGATION CONT.

I. Beginning September 1, 2001, the State of Texas offers incentives to buyers of vehicles that meet stringent emissions standards.

- Diesel replacement incentive $15,000-$25,000 depending on emissions
- Light-duty vehicle incentive $1,250-$5,000 depending on emissions

In addition, the Texas Railroad Commission, through its Alternative Fuels Research and Education Division, offers rebates for private light-duty LPG vehicles and school buses.

- LPG private vehicle rebate $1,000
- LPG school-bus rebate $6,400

How would these rebates and incentives affect the recommendation to the user in your scenarios? _____

_____

11. Choose a spokesperson to review your scenario and conclusions for the class in a 3-5 minute presentation.

12. After all groups have made their presentations, your teacher will lead a discussion on other factors that affect fuel choices in real life.

Spelled-out generic formula

$$\left(\frac{N \times M}{G} \times F\right) + \frac{E \times N}{Y} = \text{Cost per year}$$

$$\frac{\text{number of vehicles} \times \text{mileage of vehicle per year}}{\text{conventional mpg}} \times \text{price per gallon equivalent} = \text{annual fuel costs}$$

$$\frac{\text{Extra equipment cost} \times \text{number of vehicles}}{\text{life span of each vehicle (years)}} = \text{amortized equipment costs}$$

$$\text{annual fuel costs} + \text{amortized equipment costs} = \text{cost per year}$$

CONVERSIONS THAT MAKE CENTS INVESTIGATION CONT.

The Florist

Ian McShan owns a flourishing florist business in a moderate nonattainment area. He uses 20 five-year-old minivans for deliveries. As a nature lover, he feels compelled to investigate the use of alternative fuels for his business. He also thinks he may gain new customers if he "goes green." Each of his vans gets about 17 mpg on gasoline and travels about 350 miles a week or 18,200 miles per year.

Figure 2-4-6 Scenario one

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CONVERSIONS THAT MAKE CENTS INVESTIGATION CONT.

The Bus Fleet

Jennifer Hu is the transportation director for a small school district in an industrial area of a severe nonattainment city. The district is required by law to choose an alternative fuel to power most of its vehicles by 2005. Ms. Hu wants to begin by replacing five of the district's 25 full-size school buses each year, starting this year. Each bus travels about 12,000 miles each school year, and a few are used on out-of-town trips. The buses are three years old and get about 6 mpg.

Figure 2-4-7 Scenario two

CONVERSIONS THAT MAKE CENTS INVESTIGATION CONT.

The Plumber

Eusebio Barrera owns a plumbing business in a serious nonattainment area. He has ten gasoline-powered vans that his employees drive about 13,000 miles a year each. The ten vans are seven years old. His sister Pilar, an accountant, wants him to investigate ways to qualify for tax breaks, and suggested looking into alternative fuels as a means of reducing costs. Barrera, who has several grandchildren, is also concerned about reducing ozone and carbon monoxide pollution. The full-size vans get about 13 mpg now.

Figure 2-4-8 Scenario three

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CONVERSIONS THAT MAKE CENTS INVESTIGATION CONT.

The Family

Lakeisha Washington is a teacher who has decided not to work outside the home for a few years to focus on caring for her young daughter. She and Gordon, her husband, are looking for ways to trim the family budget. As residents of a marginal nonattainment area, they also want to do their part for cleaner air—for themselves and for their child. Lakeisha drives a eight-year-old full-size passenger sedan about 15,000 miles a year, averaging about 32 mpg on gasoline. Gordon rides his 24-pound bicycle to work.

Figure 2-4-9 Scenario four

CONVERSIONS THAT MAKE CENTS INVESTIGATION CONT.

The Private School

Cindy Petrovski and her husband, Thien Nguyen, are starting a private elementary school in a small town near a serious nonattainment area. They want to emphasize environmental and health issues in the curriculum, and the couple has decided to "practice what they teach." Because the school will provide pick-up service for some students, they are considering switching to an alternative fuel for their full-size van. The couple estimates they will put 20,000 miles a year on their three-year-old van, which gets 10 mpg on gasoline.

Figure 2-4-10 Scenario five

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CONVERSIONS THAT MAKE CENTS INVESTIGATION CONT.

The Foundation Repairer

Martha Lacroix operates a foundation repair business in a severe nonattainment area. She is considering replacing two six-year-old medium-duty diesel trucks to alternative fuels during the next business year. Each of the trucks travels about 10,000 miles a year and gets 6 mpg. Lacroix's partner, Jim Dutton, is not receptive to the change. Lacroix plans to convince him with the "bottom line."

Figure 2-4-11 Scenario Six

CONVERSIONS THAT MAKE CENTS INVESTIGATION CONT.

Enter from scenario or charts:

Variable	Symbol	Answer
Number of vehicles	N	
Mileage per vehicle per year	M	
Conventional mpg	G	
Vehicle life expectancies (miles)	L	
Life span of vehicle (L / M) (years)	Y	

Scenario name:
Vehicle name:
Team Members:

Variable	Symbol	Gasoline	Biodiesel	CNG	CNG/ Gasoline
Extra equipment cost ($)	E	0			
Price* ($)	F				

Variable	Symbol	E85/ Gasoline	M85/ Gasoline	Propane	Propane/ Gasoline
Extra equipment cost ($)	E				
Price* ($)	F				

Enter correct generic formula:

*Price of fuels in gasoline gallon equivalent (price per 114,250 Btu)
Source: U.S. D.O.E., Alternative Fuel Price Report, 10/9/00*

Figure 2-4-12a Student worksheet

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CONVERSIONS THAT MAKE CENTS INVESTIGATION CONT.

Scenario Name: _____

Apply generic formula for each fuel

Type of Fuel: _____

= $ _____ per year

Type of Fuel: _____

= $ _____ per year

Type of Fuel: _____

= $ _____ per year

Type of Fuel: _____

= $ _____ per year

Type of Fuel: _____

= $ _____ per year

Type of Fuel: _____

= $ _____ per year

Figure 2-4-12b Student worksheet

Conversion That Make Cents Resource List

www.fueleconomy.gov
U.S. Department of Energy; U.S. Environmental Protection Agency
Mileage estimates and side-by-side comparisons of conventional and alternative fuel vehicles.

http://math.rice.edu/~lanius/Algebra/rentacar.html
Rice University
Fun and Sun Rent-a-Car, a lesson on linear functions that uses graphs, tables, functions and systems of linear equations; aligns with TEKS and national algebra and pre-algebra standards.

http://forum.swarthmore.edu/dr.math/
Swarthmore College
"Dr. Math," a mathematics forum for elementary, middle-school, high-school and college students. Posts frequently asked questions, offers a searchable math library, and takes online questions.

http://www.cis.yale.edu/ynhti/curriculum/units/1987/6/87.06.02.x.html#a
Yale-New Haven Teachers Institute
A unit designed to increase middle-school students' understanding of internal-combustion engines; includes 21 math problems focused on transportation.

http://www.howstuffworks.com/question477.htm
Howstuffworks.com, Inc.
Explains how a car's speed affects fuel efficiency; includes a table of gas mileage versus speed for various sizes of cars.